4 ENVIRONMENTAL CONSEQUENCES OF ALTERNATIVES

This Chapter of the Final Environmental Impact Statement (FEIS) for the Mars Exploration Rover–2003 (MER–2003) project presents information on the potential environmental impacts of a Delta II 7925 and a Delta II 7925 Heavy (7925H) launch with the MER–2003 spacecraft payload. The impacts are examined for two areas: (1) the region within 100 kilometers (km) (62 miles (mi)) of Cape Canaveral Air Force Station (CCAFS), Florida (called the regional area of interest), and (2) the global environment.

4.1 ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

NASA proposes to continue preparations for and to implement the MER–2003 project. The MER–2003 project involves two launches in 2003 (the MER–A mission and MER–B mission) of identical spacecraft from Space Launch Complex 17 (SLC–17) at CCAFS. The MER–A launch, aboard a Delta II 7925, would occur during May or June, 2003. The MER–B launch would occur during June or July, 2003, aboard a Delta II 7925H. The project would send two identical rovers to separate locations on the surface of Mars to conduct *in situ* mineralogy and geochemistry investigations and characterize a diversity of rocks and soils which may hold clues about past water activity.

Each rover's science payload would include two instruments that contain small quantities of radioactive material used for instrument calibration or science experiments. The Mössbauer Spectrometer would contain two cobalt-57 sources, with a total activity that would not exceed 350 millicuries (mCi). The Alpha Particle X-Ray Spectrometer (APXS) would contain a curium-244 source that would not exceed 50 mCi. Initial thermal analyses for Mars surface operations indicated up to eleven (11) radioisotope heater units (RHUs) could be required for each rover. As the mission design matures, ongoing thermal analyses for surface operation of the rovers may indicate a requirement for fewer RHUs. Each RHU would provide about 1 watt of heat derived from the radioactive decay of 2.7 grams (g) (0.095 ounce (oz)) of plutonium (mostly Pu-238) dioxide (PuO_2) in ceramic form. Each RHU would contribute approximately 33.2 curies (Ci) to the total plutonium dioxide inventory of 365 Ci on each rover, based on the current maximum requirement of 11 RHUs.

4.1.1 Environmental Consequences of Preparing for the MER–2003 Launches

Launch vehicle and payload processing at CCAFS typically involves the use of hazardous materials and generates hazardous, solid, and liquid wastes and air emissions. Processing of a Delta II 7925 or Delta II 7925H launch vehicle would entail activities common to all Delta II launches at CCAFS.

Hazardous materials management, hazardous waste management, and pollution prevention programs are in place at CCAFS. Airborne emissions from liquid propellant loading and off-loading of the spacecraft and the launch vehicle are closely monitored using vapor detectors. Systems for loading hypergolic fuels (which ignite spontaneously when mixed together) use air emission controls (scrubbers, oxidizers, and closed loop designs) (USAF 1998). Thus, processing the launch vehicles and payloads would not cause substantial environmental impacts.

4.1.2 Environmental Impacts of Normal MER–2003 Launches

The primary environmental impacts of a normal launch would be associated with airborne emissions, particularly from the nine strap-on graphite-epoxy solid rocket motors (called GEMs) used on the Delta II 7925 launch vehicle or the nine Large Diameter Extra Long (LDXL) GEMs used on the Delta II 7925H . Air emissions from the liquid propellant engines on the Delta II core vehicle, although large in magnitude, would be relatively inconsequential in terms of environmental effects. This is discussed further in Sections 4.1.2.2 and 4.1.2.3.

4.1.2.1 Land Use

Land areas on and around SLC–17 are currently within the launch operations land use category (USAF 1998). The general plans of Brevard County and the City of Cape Canaveral designate compatible land uses around Cape Canaveral. At CCAFS, launch of a Delta II vehicle would be consistent with the designated land use of the facility.

4.1.2.2 Air Quality

The USAF's Rocket Exhaust Effluent Diffusion Model (REEDM) has been used at CCAFS to predict exhaust emission concentrations from a variety of launch vehicles. This model has been used in previous USAF and NASA environmental documentation to evaluate the emission concentrations from both a normal launch and from accident conditions for various Delta II launch vehicle configurations (USAF 1998, NASA 1998a, NASA 1998b, and NASA 2002).

The REEDM analyses performed for the *New Millennium Program Final Programmatic Environmental Assessment* (NASA 1998a) and the *Space Infrared Telescope Facility Environmental Assessment* (NASA 2002) were examined and are assumed to be typical. These two documents, respectively, address the Delta II 7925 (the MER–A launch vehicle) and the Delta II 7925H (the MER–B launch vehicle). The REEDM analyses prepared for both documents assumed meteorological conditions that would be acceptable for launch but which could result in the highest exhaust product concentrations in populated areas near CCAFS. None of these analyses predicted substantial adverse impacts to the air quality in populated areas near CCAFS due to the launches under consideration.

A normal launch would result in combustion emissions from first stage main engines and the six ground-lit solid rocket motors. The first stage of the Delta II core vehicle, fueled by rocket propellant-1 (RP-1) and liquid oxygen (LOX), would primarily produce carbon monoxide (CO), carbon dioxide (CO_2), and water (H_2O) as combustion products. The emission products of the GEMs on the Delta II 7925 and the LDXL GEMs on the Delta II 7925H would consist primarily of aluminum oxide (Al_2O_3) particulates, CO, hydrogen chloride (HCl), nitrogen (N_2), and H_2O. Under the high temperatures of the GEMs' exhaust the CO would be quickly oxidized to CO_2 and the N_2 may react with ambient oxygen to form nitrogen oxides (NO_X), but such afterburning would diminish quickly as the plume expands and cools (Zittel 1995).

Emissions from a typical Delta II launch would form a cloud of about 100 m (328 ft) in diameter at the launch pad during the first few seconds after ignition and liftoff. This high-temperature cloud would be buoyant and would rise to a height ranging from about 670 to 1,340 m (about 2,200 to 4,400 ft) near the launch area. The cloud would then dissipate through mixing with the atmosphere. Exhaust products would also be distributed along the vehicle's flight path, but emissions per unit length of trajectory would decrease as the vehicle accelerates. An area of about 80 m (262 ft) in the vicinity of the launch pad would be directly impacted by the exhaust flames.

The results of REEDM analyses are typically compared to the following recommended guidelines. The Emergency Response Planning Guidelines (ERPG), developed by the American Industrial Hygiene Association, represent the maximum airborne concentration levels below which it is believed nearly all individuals could be exposed for up to one hour without (1) experiencing adverse health effects; (2) perceiving clearly defined objectionable odor; or (3) experiencing or developing life-threatening health effects. The Short-term Public Emergency Guidance Level (SPEGL) is an advisory recommendation from the National Research Council for single, short-term, emergency exposures of the general population, and consider members of sensitive populations, such as children, the aged, and persons with serious, debilitating diseases. National Ambient Air Quality Standards (NAAQS), established by the U.S. Environmental Protection Agency (EPA) to allow "an adequate margin of safety ... to protect public health" (42 U.S.C. §7409(b)), apply only to stationary sources, but are also considered for comparison purposes.

Based upon the REEDM analyses performed for previous USAF and NASA environmental documentation (USAF 1998, NASA 1998a, NASA 1998b, and NASA 2002), and the assumption that they are representative of the MER–2003 launches, emissions from normal launch of the MER–2003 missions would not exceed any of the standards or guidelines, and would not create adverse impacts to air quality in the region.

4.1.2.3 Global Environment

Upper Atmosphere. Launch of a Delta II 7925 or a Delta II 7925H would result in the deposition of ozone-depleting chemicals from the combustion products released along the launch vehicle's trajectory through the stratosphere. NASA has examined the potential impact of a Delta II 7925 emissions in the stratosphere. The principal ozone-depleting chemicals in exhaust emissions would be HCl, NO_X, and Al_2O_3 particulates. Because of uncertainties about the current loading of ozone-depleting chemicals in the atmosphere, the effects of a single launch can more accurately be calculated as a percentage increase in the rate of ozone depletion relative to the No Action Alternative. The rate of increase in ozone depletion has been calculated to be 3.1 x 10^{-5}% of the annual average global ozone depletion rate per metric ton (mt) (2.8 x 10^{-5}% per ton) of HCl emissions, 1.8 x 10^{-6}% per mt (1.6 x 10^{-6}% per ton) of NO_X, and 8.3 x 10^{-6}% per mt (7.5 x 10^{-6}% per ton) of Al_2O_3 (Jackman *et al.* 1998).

Using these ozone depletion rates and the total mass of each of these combustion products emitted by a Delta II 7925, an estimate of ozone depletion was developed. This estimate is conservative because it assumes that the entire mass of these exhaust products would migrate to the stratosphere (Jackman *et al.* 1998), even though the majority of emissions occur in the lower atmosphere and would mostly not reach the stratosphere.

A Delta II 7925 would emit a total of about 22,289 kilograms (kg) (49,139 pounds (lb)) of HCl, about 37,902 kg (83,558 lb) of Al_2O_3, about 8,792 kg (19,382 lb) of NO_x, and about 299 kg (658 lb) of chlorine during launch (Kelley 2002, NASA 2001). Applying the ozone depletion rates estimated for each of these exhaust products, the stratospheric ozone depletion rate associated with a Delta II 7925 launch would be approximately 0.001% of the annual average global ozone depletion rate that would occur under the No Action Alternative.

Using the ozone depletion rates stated above and the total mass of each of the combustion products emitted by a Delta II 7925H, an estimate of ozone depletion was developed. Emissions would generally be higher for a Delta II 7925H than for a Delta II 7925 because of the larger amount of solid propellant in the LDXL GEMs. The estimate for the Delta II 7925H is conservative because it assumes that the entire mass of these exhaust products would migrate to the stratosphere, even though the majority of emissions occur in the lower atmosphere.

Based on these assumptions, a Delta II 7925H would emit a total of about 31,634 kg (69,740 lb) of HCl, about 54,447 kg (120,033 lb) of Al_2O_3, about 12,458 kg (27,466 lb) of NO_x, and about 343 kg (756 lb) of chlorine during launch (Kelley 2002, NASA 2001). Applying the ozone depletion rates estimated for each of these exhaust products, the stratospheric ozone depletion rate associated with a Delta II 7925H launch would be less than 0.0015% of the annual average global ozone depletion rate that would occur under the No Action Alternative.

Ozone depletion would occur along the trajectory of each launch vehicle, but it has been estimated that the depletion "trail" from a launch vehicle is largely temporary and would be self-healing within a few hours of passage (AIAA 1991). Cumulative impacts are discussed in Section 4.3.

Global Warming. Launch of a Delta II 7925 or a Delta II 7925H would result in the emission of global warming gasses. These would primarily be CO_2, though there may be trace emissions of nitrous oxide (N_2O) emitted by the solid rocket motors. Both the core and the solid rocket motors would also emit carbon monoxide (CO) which would quickly react with oxygen in the atmosphere to form CO_2. The Delta II core vehicle would emit 27,973 kg (61,670 lb) of CO_2 and 40,266 kg (88,770 lb) of CO. The nine GEMs on the Delta II 7925 combined are calculated to emit 2,706 kg (5,966 lb) of CO_2, and 22,463 kg (49,522 lb) of CO, yielding a combined total emission of 30,679 kg (67,636 lb) of CO_2 and 62,729 kg (138,292 lb) of CO for the Delta II 7925 (Kelley 2002). The nine LDXL GEMs on the Delta II 7925H are calculated to emit 3,122 kg (6,884 lb) of CO_2 and 35,809 kg (78,945 lb) of CO, yielding a combined total emission of 31,096 kg, (68,554 lb) of CO_2 and 76,076 kg (167,715 lb) of CO for the Delta II 7925H (Kelley 2002). For comparison, the U.S. emitted 5.8×10^{12} kg (12.8×10^{12} lb) of CO_2 during 2000, with total greenhouse gas emissions (including substances such as methane, nitrous oxide, and hydrocarbons) equivalent to 7.0×10^{12} kg (15.4×10^{12} lb) of CO_2 (EPA 2002). Cumulative impacts are discussed in Section 4.3.

4.1.2.4 Noise

Space vehicle launches generate intense noise levels over short periods of time at the launch pad and are relatively infrequent (tens of events per year). The highest noise levels for a space vehicle launch (160 A-weighted decibels (dBA)) have been recorded at the launch pad and supporting facilities during a Space Shuttle launch. Noise measurements for a Delta II launch vehicle were recorded in 1992 at distances of about 450 meters (m), 600 m, and 900 m (1,500 feet (ft), 2,000 ft, and 3,000 ft) from SLC–17 (see Figure 4-1). The noise pressure levels varied from about 120 dBA at 450 m (1,500 ft) to 115 dBA at 900 m (3,000 ft). These levels would occur for less than two minutes during the launch, and diminish rapidly as the launch vehicle gains altitude and moves downrange over the Atlantic Ocean (USAF 1998). Launch site workers would be a minimum of 2,000 m (6,500 ft) away from the launch pad at SLC–17 at the time of the Delta II launch. They would be exposed to noise levels well below Occupational Safety and Health Administration regulations for unprotected workers (140 dBA maximum, 115 dBA 15-minute average).

While some area residents may experience momentary annoyance, the noise levels outside the CCAFS property boundary would not exceed the EPA's maximum 24-hour average exposure level of 70 dBA and would present no health hazard (NASA 1998a). By comparison, vehicular traffic noise levels range from about 85 dBA for an automobile to 110 dBA for a motorcycle.

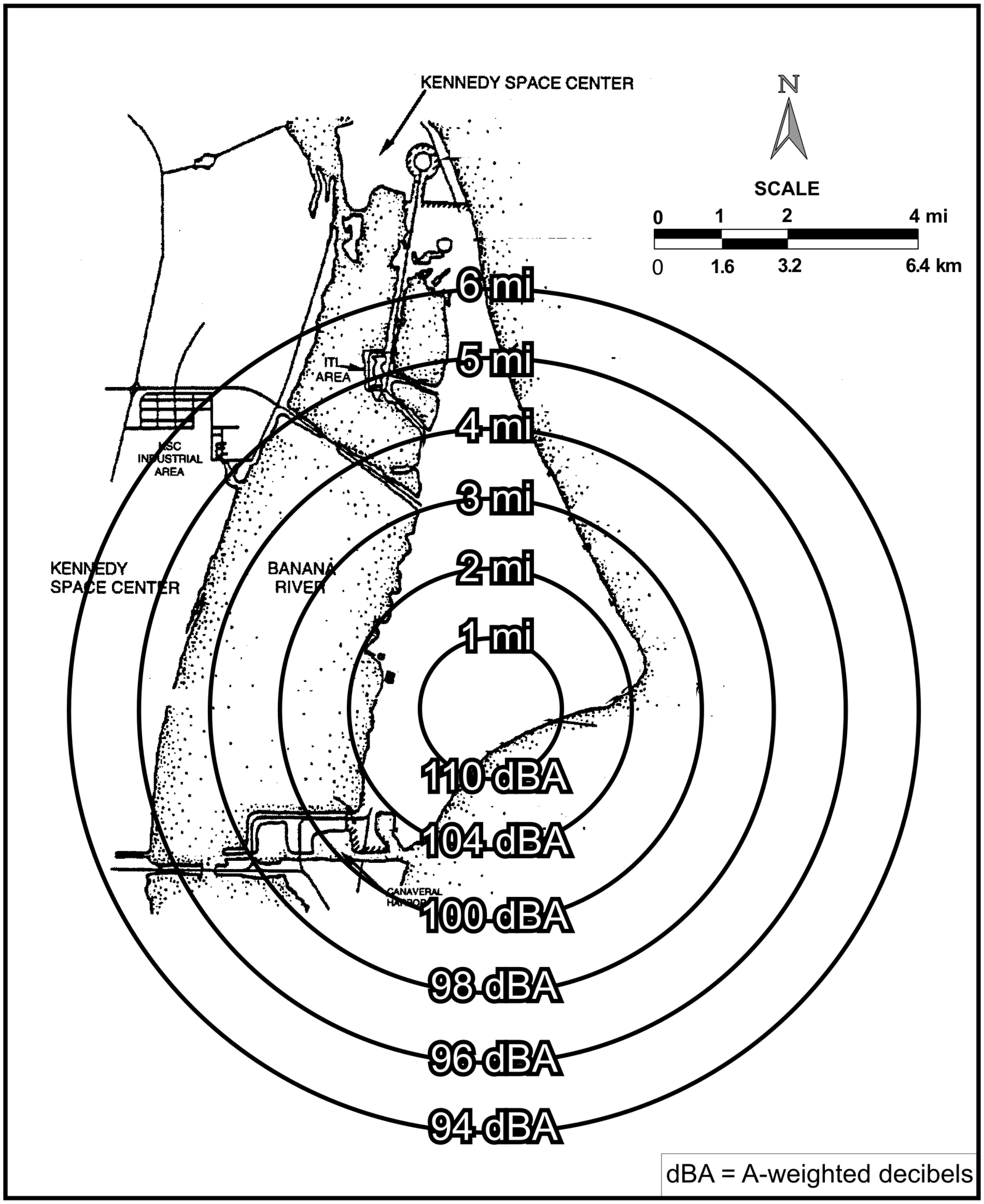
Noise generated from a launch of a Delta II 7925H is expected to be slightly higher than for a Delta II 7925 launch (see Figure 4-1), but less than for a Space Shuttle or Titan IV launch. SLC–17 Pad B has been modified to use water for noise suppression, so noise levels away from CCAFS should be comparable to those of a Delta II 7925 (NASA 2002).

The short-term elevation of noise levels generated by the launch of either launch vehicle would probably disturb terrestrial biota near the launch complex, but is not expected to result in long-term adverse impacts (USAF 1996).

Sonic booms are associated with normal launches of any vehicles, but occur over the ocean, downrange of populated areas (NASA 1998a; NASA 1998b; USAF 1996). No adverse impact to human populations would be expected. Ships and other vessels in the area potentially affected would be warned in advance of launch events and are not expected to be adversely affected.

4.1.2.5 Geology and Soils

No impacts to geology would be expected. A Delta II 7925 or 7925H launch would result in deposition of solid rocket exhaust products (primarily Al_2O_3 and HCl) onto soils. Deposition of particulate Al_2O_3 would occur primarily in the vicinity of the launch complex, but depending on the particle size distribution and winds, appreciable deposition could also occur downwind. Wet deposition of HCl could occur as exhaust chlorides mix with entrained deluge water and with water contained in the exhaust of the first stage engine, but the majority of HCl is swept into the flame trench. Wet deposition of chlorides would be limited to within a few hundred meters of the launch pad. If rain passed through the exhaust ground cloud shortly after launch, wet HCl deposition could occur at further distances from the launch complex. The soils at CCAFS have relatively high buffering capacities and are not expected to be adversely affected (NASA 1998b; USAF 1998).



Source: Adapted from NASA 1998a

Figure 4-1. Peak Noise Generated by a Delta II 7925 Launch from CCAFS SLC–17

4.1.2.6 Hydrology and Water Quality

There are two principal sources of potential launch area impacts to groundwater and surface water resources associated with a normal launch: disposal of spent deluge water collected at the SLC–17 launch pads, and the deposition of launch exhaust products from the exhaust cloud into nearby surface water bodies. For a Delta II 7925 launch, about 111,600 liters (29,500 gallons (gal)) of water would be utilized for deluge, fire suppression, and washdown at Pad A (USAF 1994) and about 143,054 liters (37,800 gal) for a Delta II 7925H launch at Pad B (Giles 2001). The water would be supplied from local municipal sources and no groundwater would be withdrawn.

Exhaust from the Delta II 7925 GEMs and Delta II 7925H LDXL GEMs would cause the primary water impacts. No impacts would be expected from exhaust from the liquid rocket engines.

<u>Groundwater</u>. At CCAFS, the deluge, fire suppression, and washdown water collected in the catch basins of launch complexes would be monitored for water quality (NASA 1998a; NASA 1998b; USAF 1996). The water would be held and treated, if necessary, to reduce contaminant levels (or adjust pH) prior to release to grade in accordance with a Florida Department of Environmental Protection wastewater discharge permit. The water discharged to grade would percolate through soil to the groundwater table and flow west towards the Banana River (Schmalzer *et al.* 1998). The water would be further neutralized during its passage through the soil, such that some of the contaminants that would not be removed during treatment would also be removed. It is not expected that groundwater quality would be substantially affected by the discharge of deluge, fire suppression, and washdown water.

<u>Surface Water</u>. Surface water runoff from SLC–17 flows west towards the Banana River (Schmalzer *et al.* 1998). Depending on wind conditions, the launch exhaust cloud could drift over the Atlantic Ocean or the Banana River near CCAFS. Surface waters in the area of the exhaust cloud might acidify from deposition of HCl. The large volumes of the water bodies in the vicinity of CCAFS, combined with their natural buffering capacity, suggest that the reduced pH caused by acidic deposition would return to normal levels within a few hours (USAF 1996). Al_2O_3 particles would also settle from the exhaust cloud. Al_2O_3 is relatively insoluble at the pH of the local surface waters and particles would settle down to sediments. Long-term elevation of aluminum levels in the water is not expected.

4.1.2.7 Offshore Environment

The solid rocket motor casings, the first stage, and the payload fairing (PLF) of each Delta II launch vehicle would be jettisoned and land in deep ocean areas where the metal parts would eventually corrode. Toxic concentrations of metals would be unlikely because of slow corrosion rates and the large volume of ocean water available for dilution (USAF 1996). Launch vehicle missions are nominally designed such that all first stage fuel is depleted at the time of main engine cut-off. Any residual propellant in spent stages would be released to the water column. RP-1 fuel in the Delta II first stage is weakly soluble and any residual amounts would be expected to migrate to the ocean surface where it would evaporate. Any small amounts of residual propellants in either the GEMs or the LDXL GEMs would be released slowly and should not reach toxic concentrations except in the immediate vicinity of the motors.

4.1.2.8 Biological Resources

Terrestrial and Aquatic Biota. Terrestrial fauna and flora at CCAFS would be largely unaffected by the launch except near the launch pad (NASA 2002). High temperatures would damage or kill biota within the launch cloud. However, damage would occur primarily in the immediate vicinity of the launch complex, and long-term population effects on terrestrial biota are not expected. Acid deposition is unlikely to harm terrestrial biota.

The exhaust clouds from the Delta II 7925 and the Delta II 7925H should not significantly affect aquatic biota in nearby water bodies (USAF 1996). There has been no evidence of fish kills in either the Banana River or the Atlantic Ocean from a launch at CCAFS (NASA 1998a; NASA 1998b).

Threatened or Endangered Species. At CCAFS, no scrub jay mortality is expected based on studies during and following Titan IV launches in 1990. Fire caused by a launch in 1990 caused extended scrub jay scolding behavior, however, the jays avoided the burned area for about one month (USAF 1998). Other bird species, such as wood storks and bald eagles, may be temporarily disturbed, but no long-term effects would be expected.

Sea turtles are sensitive to lighting near nesting beaches. If lighting inland is brighter than reflected light of the moon and stars on the ocean, hatchlings may become confused, head the wrong way, and never reach the water. A light management plan is in force at SLC–17.

The short-term elevation of noise levels generated by the launch of either launch vehicle would probably disturb terrestrial biota near the launch complex but is not expected to result in long-term adverse impacts (USAF 1996).

4.1.2.9 Socioeconomics

Launch of a Delta II 7925 and a Delta II 7925H from CCAFS for the MER–2003 missions would be part of the normal complement of launches at the facility. These launches would result in negligible impacts to socioeconomic factors such as demography, employment, transportation, public or emergency services.

4.1.2.10 Environmental Justice

Neither of the MER–2003 launches would result in disproportionate adverse impacts on low income or minority populations. See Appendix B for further details.

4.1.2.11 Cultural Resources

CCAFS SLC–17 is an active launch complex and is eligible for listing on the National Register of Historic Places because of its significance as the longest continually active launch site in the United States and its association with events that have made a significant contribution to history (USAF 1996). The USAF has requested guidance from the State Historic Preservation Officer on how to best preserve the historical significance of SLC–17 while it continues to serve the Nation's space program. Launch of the MER–2003 Delta II vehicles would not affect its status, so no impacts are expected.

4.1.3 Environmental Impacts of Potential MER–2003 Project Nonradiological Accidents

The potential environmental impacts associated with Delta II accidents have been discussed in previous USAF and NASA NEPA documentation and are summarized here.

A variety of accidents could occur during preparations for and launch of any launch vehicle. Only two types of nonradiological accidents would have potential consequences: a liquid propellant spill during fueling operations and a launch failure. The potential consequences of these accidents are presented below.

4.1.3.1 Liquid Propellant Spill

The Delta II core vehicle uses RP-1 (a thermally stable kerosene) and LOX in the first stage, and Aerozine–50 (a 50:50 mix of hydrazine and unsymmetrical dimethylhydrazine) and nitrogen tetroxide (N_2O_4) in the second stage. Standard practices such as closed-loop fueling are maintained during loading operations. Standard procedures for loading hypergolic fuels include sealed transfer systems, wet scrubbing, and oxidation, and only very small fugitive emissions (on the order of grams) are expected (USAF 1998). The most severe propellant spill accident scenario postulated involves release of the entire contents of the second stage N_2O_4 tank during propellant transfer (NASA 1998a). Because N_2O_4 rapidly converts to NO_X in the air, toxic effects of the release would be limited to the immediate vicinity of SLC–17. Using REEDM modeling results for a similar spill postulated for a Titan launch vehicle and scaled for a Delta II propellant load, airborne levels of NO_X would reduce to 5 parts per million (ppm) within about 150 m (500 ft) of the spill and to 1 ppm within about 300 m (984 ft) (NASA 1998b). Activating the launch pad water deluge system would substantially reduce the evaporation rate of spilled propellant, limit potential exposures in the vicinity of the spill, and in turn reduce the amount of propellant dispersed downwind. During fueling operations, propellant transfer personnel are equipped with protective clothing and breathing apparatus, and uninvolved personnel are excluded from the area. USAF safety requirements specify that plans and procedures be in place to protect the workforce and the public during fueling operations (USAF 1997).

4.1.3.2 Launch Failures

A launch vehicle accident either on or near the launch pad presents the greatest potential for nonradiological impacts to human health, principally to workers at the launch site. Range Safety requirements mandate a flight termination system on the Delta II (see Section 2.1.5.5). In the event of either a command or an automatic destruct event, the propellant tanks and solid motor casings on the Delta II would be ruptured, and the launch vehicle would be destroyed. The potential short-term effects of an accident would include a localized fireball, falling fragments from explosion of the vehicle, release of uncombusted propellants and propellant combustion products; and, for on-pad or very low altitude explosions, death or damage to nearby biota and brush fires near the launch pad.

The USAF modeled postulated accidents at CCAFS involving combustion of Delta II 7925 and Delta II 7925H propellants. Results of these analyses have been reported in previous NASA environmental documents (NASA 1998a and NASA 2002, respectively). Typical unfavorable meteorological conditions were used for the REEDM analyses to model transport of the exhaust cloud. Release and combustion of both liquid and solid propellants were assumed to be involved. For these modeled accidents, the principal constituents resulting from burning propellant were estimated to be CO, Al_2O_3, and HCl. Although Al_2O_3 would be deposited from the explosion cloud as it was carried downwind, little wet deposition of HCl would be expected unless rain falls through the explosion cloud. The estimated concentrations of combustion products resulting from these postulated accidents were found to be well within prescribed guidelines and standards. Based upon these REEDM analyses and the assumption that they are representative of the MER–2003 launches, emissions resulting from accidents during either of the MER–2003 launches would not exceed any of the recommended guidelines and standards, and would not create adverse impacts to air quality in the region.

Parts of the exploded vehicle would fall back to earth. Except for on-pad or very near-pad accidents, most of the fragments would fall into the ocean, where the metal parts would eventually corrode. Toxic concentrations of metals would be unlikely because of slow corrosion rates and the large volume of ocean water available for dilution (USAF 1996).

Uncombusted solid rocket propellant would dissolve slowly and should pose no long-term threat since ocean systems would only temporarily be impacted and would recover rapidly through dispersion. There would probably be no impact to aquatic biota except in the immediate vicinity of the solid rocket motors. Residual RP-1 fuel is weakly soluble, would spread over the surface of the water, and should evaporate within a few hours resulting in only a short-term impact to aquatic biota. Hypergolic fuels would either be consumed or disperse in the atmosphere without entering the ocean.

On January 17, 1997 a Delta II 7925 launch vehicle failed when one of the GEMs failed structurally 7.2 seconds after liftoff from SLC–17. The Automatic Destruct System was activated by the initial GEM failure, followed by a Command Destruct System activation issued by the Range Control Officer (now called the Mission Flight Control Officer (MFCO)), preventing hazard to the public. The vast bulk of the plume that resulted occurred over the Atlantic Ocean, with localized maximum ground concentrations of HCl and NO_2 at levels of 1 to 2 ppm, respectively. A high altitude, visible plume also extended over large parts of Brevard and Indian River counties. While ground concentrations from this plume were not hazardous, the general public was not immediately notified that the accident had occurred. To ensure that the public would be notified of any accident in a timely manner, CCAFS now has a Brevard County Emergency Management Center representative at the launch console beginning two hours before launch. This representative has direct audio and video communications links to the Center in Rockledge, Florida. The USAF has also installed a direct emergency phone line to the Florida State Emergency Response Center (NASA1998b).

4.1.4 Radiological Accident Assessment

This section is summarized from the U.S. Department of Energy's (DOE) *Nuclear Risk Assessment for 2003 Mars Exploration Rover Project Environmental Impact Statement* (DOE 2002). NASA, and DOE and its contractors have conducted safety assessments of launching and operating spacecraft using RHUs (*e.g.*, the Galileo mission in 1989, the Mars Pathfinder mission in 1996, the Cassini mission in 1997, and the proposed Mars Surveyor 2001 mission[1] in 1999). NASA and DOE, therefore, have built upon an extensive experience base that involves:

- testing and analysis of the RHUs under simulated launch accident environments;
- evaluating the probability of launch-related accidents based on evaluation of launch histories, including extensive studies of the January 1997 Delta II accident at CCAFS, and system designs; and
- estimating the outcomes of the RHU and small-quantity radioactive source responses to the launch accident environments.

The risk assessment for the MER–2003 missions began with identification of initial launch vehicle system failures and the subsequent chain of accident events that could ultimately lead to the accident conditions (*e.g.*, explosive overpressures, fragments, fire) that could threaten the RHUs and small-quantity radioactive sources onboard the MER–A and MER–B spacecraft. Based on Delta II system reliabilities and failure probabilities, accident initial conditions that could lead to failure of the launch vehicle were identified across all major mission phases.

NASA then identified the specific accident outcome environments that could potentially threaten the RHUs and small-quantity radioactive sources. DOE determined the response of the sources to these accident environments and estimated the amount of radioactive material that could potentially be released. DOE utilized the results of modeling and data from its RHU testing and analyses during the early 1980s in support of the Galileo mission and the mid 1990s in support of the Cassini mission to determine if a release of radioactive material from a RHU could potentially occur.

The nuclear risk assessment for the MER–2003 Project considers 1) potential accident scenarios associated with the launch of the MER–A and MER–B mission spacecraft, and their probabilities and accident environments; 2) the response of the RHUs and small-quantity radioactive sources to such accidents in terms of release source terms and their probabilities; and 3) the radiological consequences and mission risks associated with such potential releases. This section addresses the first two items and Section 4.1.5 addresses the third item. For the purpose of the analysis performed for this FEIS, the following inventory of radioactive materials was assumed to be onboard each rover.

---

[1] A risk assessment was being prepared for the Mars Surveyor 2001 lander-rover mission when that mission was cancelled.

- Plutonium-238 (Pu-238): 33.2 curies (Ci) in each of up to 11 RHUs (an alpha emitter with a half-life of 87.7 years; the activity includes minor contributions from other related plutonium and actinide radionuclides);
- Curium-244 (Cm-244): 0.05 Ci (an alpha emitter with a half-life of 18.1 years); and
- Cobalt-57 (Co-57): 0.35 Ci (a gamma emitter with a half-life of 271 days).

The amount released for each accident scenario was used to determine the potential consequences of the release to the environment and to people. The approach used was similar to that used in the Galileo, Mars Pathfinder, Cassini, and Mars Surveyor 2001 risk assessments.

For the purpose of the risk assessment, the MER–A mission on the Delta II 7925 launch vehicle was divided into five mission phases on the basis of the mission elapsed time (the time (T) in seconds (s) after liftoff) of principal events as follows:

- Phase 0 (Pre-Launch, T < 0 s);
- Phase 1 (Early Launch, 0 s ≤ T < 23 s, after which most debris and intact vehicle configurations resulting from an accident would impact water);
- Phase 2 (Late Launch, 23 s ≤ T < 297 s, at payload fairing (PLF) separation following first and second stage separation);
- Phase 3 (Pre-Orbit/Orbit, 297 s ≤ T < 640 s, when the Command Destruct System (CDS) is disabled); and
- Phase 4 (Orbit/Escape, 640 s ≤ T < 2237 s, at MER–2003 spacecraft escape).

Differences between the Delta II 7925 and Delta II 7925H vehicle trajectories and mission profiles for the MER–A and MER–B missions result in slight differences in the mission phase timing for the MER–B mission. For MER–B, Phase 3 ends at 589 s and Phase 4 ends at 3434 s.

4.1.4.1 Accident Scenarios, Probabilities and Environments

Accident scenarios, probabilities and environments are developed in detail in the EIS Databook (NASA 2001). Accident scenarios and probabilities are developed in terms of Accident Initial Conditions (AICs), defined as the first system-level indication of a launch vehicle failure that could lead to loss of the launch vehicle or to mission failure. An example of an AIC would be a trajectory control malfunction resulting in a launch vehicle deviation from its planned trajectory. The accident progression after the AIC leads to a range of possible accident outcomes in which the RHUs (and/or small-quantity radioactive sources) might first experience a potentially damaging environment. An example of an outcome would be the ground impact of various intact spacecraft/launch vehicle configurations (termed intact impact).

The accident outcomes are determined to a large degree by the Flight Termination System (FTS) actions (see Section 2.1.5.5) that occur or do not occur during the accident. If the MFCO does not respond in time and the Automatic Destruct System (ADS) does not activate, ground impact would result.

The Pre-Launch AICs generally involve conditions leading to failure of propellant tanks, drop accidents involving the Star 48B/spacecraft during stacking operations, inadvertent GEM ignition, or inadvertent FTS activation. These AICs along with their probabilities are summarized in Table 4-1, which indicates a total AIC probability of 1.16 x 10^{-4} (1 in 8,600). The Pre-Launch AICs lead to one of four outcomes defined in terms of intact impact configurations: spacecraft only, Star 48B/spacecraft, and second stage/Star 48B/spacecraft/payload fairing (PLF). The Pre-Launch probabilities are identical for both the Delta II 7925 and Delta II 7925H.

Table 4-1. Pre-Launch AIC Probabilities

AIC	Probability
SLC–17 Propellant Containment Failures	$6.00x10^{-5}$
First Stage LOX Tank Overpressure	$1.20x10^{-5}$
Star 48B/Spacecraft Stacking Failure	$2.40x10^{-5}$
Second Stage Common Bulkhead Failure	$1.80x10^{-5}$
Inadvertent FTS Activation	$1.20x10^{-6}$
Premature GEM Ignition	$1.20x10^{-6}$
Total	**$1.16x10^{-4}$**

Source: DOE 2002

The Post Lift-Off (T > 0) AICs, covering those associated with Phases 1 to 4, were developed in NASA 2001 based on Delta II launch vehicle reliability data and updated to reflect actual flight history. The types of AICs identified include:

- Trajectory control malfunction,
- Attitude control malfunction,
- Propellant tank failures,
- Catastrophic engine/motor failure,
- Structural failure,
- Inadvertent FTS activation or PLF separation, and
- Staging failure.

The specific Post Lift-Off AICs and their probabilities by mission phase are presented in Table 4-2 for the Delta II 7925. The total probability of all Post Lift-Off AICs is 3.20 x 10^{-2} (about 1 in 30). These AICs can lead to one of the following:

- Impact configurations near the launch pad or over water: spacecraft only, Star 48B/spacecraft, second stage/Star 48B/spacecraft/PLF, and full stack (entire launch vehicle including spacecraft) intact impact (FSII);
- Sub-orbital reentry; or
- Orbital reentry.

The Post Lift-Off AICs and their probabilities for the Delta II 7925H are similarly presented in Table 4-3.

Table 4-2. Post Lift-Off AIC Probabilities by Time Intervals for the Delta II 7925

	AIC Probability by Mission Phase				
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Total**
AIC	**0 – 23 s**	**23 – 297 s**	**297 – 640 s**	**640 – 2237 s**	**0 – 2237 s**
Trajectory Control Malfunction	$1.87x10^{-4}$	$7.44x10^{-3}$	$3.24x10^{-5}$	$7.59x10^{-5}$	$7.74x10^{-3}$
Attitude Control Malfunction	$5.56x10^{-4}$	$6.15x10^{-3}$	$7.07x10^{-5}$	$2.45x10^{-4}$	$7.02x10^{-3}$
First Stage Failures [a]	$5.48x10^{-4}$	$3.07x10^{-3}$	-	-	$3.62x10^{-3}$
GEM Failures [a]	$3.39x10^{-3}$	$7.35x10^{-3}$	-	-	$1.07x10^{-2}$
PLF Failures	$1.20x10^{-5}$	$9.50x10^{-5}$	-	-	$1.07x10^{-4}$
Second Stage Failures [a]	$5.38x10^{-7}$	$3.26x10^{-5}$	$2.00x10^{-4}$	$8.79x10^{-5}$	$3.21x10^{-4}$
Third Stage Failures [a]	$5.14x10^{-8}$	$4.07x10^{-7}$	$2.53x10^{-8}$	$1.81x10^{-3}$	$1.81x10^{-3}$
Spacecraft Failures	$9.58x10^{-8}$	$8.00x10^{-7}$	$1.95x10^{-7}$	$9.10x10^{-7}$	$2.00x10^{-6}$
Staging Failures	-	$9.14x10^{-5}$	-	$6.32x10^{-4}$	$7.23x10^{-4}$
Inadvertent CDS Activation	$2.16x10^{-6}$	$2.57x10^{-5}$	$3.22x10^{-5}$	-	$6.01x10^{-5}$
Total	**$4.69x10^{-3}$**	**$2.42x10^{-2}$**	**$3.35x10^{-4}$**	**$2.85x10^{-3}$**	**$3.21x10^{-2}$**

Source: DOE 2002

a. Includes failures other than ones leading to trajectory or attitude control malfunctions.

Table 4-3. Post Lift-Off AIC Probabilities by Time Intervals for the Delta II 7925H

	AIC Probability by Mission Phase				
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Total**
AIC	**0 – 23 s**	**23 – 297 s**	**297 – 589 s**	**589 – 3434 s**	**0 – 3434 s**
Trajectory Control Malfunction	$8.71x10^{-6}$	$6.65x10^{-3}$	$2.45x10^{-5}$	$8.49x10^{-5}$	$6.77x10^{-3}$
Attitude Control Malfunction	$5.55x10^{-4}$	$6.13x10^{-3}$	$5.33x10^{-5}$	$2.83x10^{-4}$	$7.02x10^{-3}$
First Stage Failures [a]	$5.48x10^{-4}$	$3.07x10^{-3}$	-	-	$3.62x10^{-3}$
GEM Failures [a]	$2.17x10^{-3}$	$6.42x10^{-3}$	-	-	$8.59x10^{-3}$
PLF Failures	$1.17x10^{-5}$	$9.53x10^{-5}$	-	-	$1.07x10^{-4}$
Second Stage Failures [a]	$4.91x10^{-7}$	$3.36x10^{-5}$	$1.71x10^{-4}$	$1.16x10^{-4}$	$3.21x10^{-4}$
Third Stage Failures [a]	$4.72x10^{-8}$	$3.85x10^{-7}$	$1.57x10^{-8}$	$1.81x10^{-3}$	$1.81x10^{-3}$
Spacecraft Failures	$8.52x10^{-8}$	$7.20x10^{-7}$	$1.11x10^{-7}$	$1.08x10^{-6}$	$2.00x10^{-6}$
Staging Failures	-	$9.14x10^{-5}$	-	$6.32x10^{-4}$	$7.23x10^{-4}$
Inadvertent CDS Activation	$2.34x10^{-6}$	$2.80x10^{-5}$	$2.98x10^{-5}$	-	$6.01x10^{-5}$
Total	**$3.29x10^{-3}$**	**$2.25x10^{-2}$**	**$2.79x10^{-4}$**	**$2.93x10^{-3}$**	**$2.90x10^{-2}$**

Source: DOE 2002

a. Includes failures other than ones leading to trajectory or attitude control malfunctions.

4.1.4.2 Accident Source Terms and Probabilities

The potential accident environments associated with launch area accident scenarios include blast (explosion overpressure), fragment, fire (burning liquid propellant and/or solid propellant), and surface impact. The accident environments for each scenario would be a function of the time of occurrence. Details of the accident environments are presented in NASA 2001 and are summarized, together with the potential response of the RHUs, in Table 4-4.

Table 4-4. Summary of RHU Responses to Accident Environments

Accident Environment	Accident Environment Severity [a, b, c, d]	RHU Response [e]
Explosion (Delta II First Stage Liquids)	0.38 to 2.8 MPa overpressure and 4.4 to 19.5 kPa-s impulse	No release
Explosion (Delta II Second Stage Liquids)	0.38 to 0.76 MPa overpressure and 0.55 to 4.2 kPa-s impulse	No release
Explosive Burn (Star 48B/GEMs)	0.53 to 2.0 MPa overpressure and 17.0 kPa-s impulse	No release
Explosion (Spacecraft Hydrazine Tanks)	0.91 to 1.3 MPa overpressure	No release
Liquid Propellant Fires	2450 K initial, decreasing to 2120 K at fireball stem lift-off (6.6 s)	No release
Solid Propellant Fires	2600 K to 3100 K for up to 500 s	Vapor release possible
Fragments	Star 48B: 2.8 mm thick Ti at ≤ 200 m/s	No release [f]
	Spacecraft Hydrazine Tank: 1 mm Al at 69 m/s without attenuation	No release
Impact	Spacecraft: < 49 m/s	No release
	Star 48B/Spacecraft: < 131 m/s	No release [f]
	Stage 2/Star 48B/Spacecraft/PLF: < 122 m/s	No release [f]
	Full Stack Intact Impact: < 212 m/s	No release [f]
Reentry	< 11 km/s @ 122 km altitude	No release

Source: DOE 2002

a. A MegaPascal (MPa) is a unit of pressure; a kiloPascal-second (kPa-s) is a unit of impulse; 1 Pascal is a unit of pressure equal to a force of 1 newton per meter squared or 0.0208 pound per square foot.
b. Kelvin (K) is a unit of absolute temperature; 0 K = –273.15° C = –459.67° F.
c. mm = millimeters; m/s = meters per second; Ti = Titanium; Al = Aluminum.
d. km/s = kilometers per second.
e. The Cm-244 and Co-57 in the science instruments would be released in liquid and solid propellant fires and during reentry.
f. Failure of graphite components possible.

Safety testing and response analyses of the RHUs to accident environments indicate that the protection provided by the graphite components and the platinum-rhodium clad encapsulating the PuO_2 (see Section 2.1.2) makes releases unlikely due to purely mechanical damage from spacecraft ground impacts, propellant blast overpressures, and debris fragments. The primary release mechanism is exposure to high-temperature burning solid propellant, which could lead to clad melting and partial vaporization of the PuO_2. Should the graphite components be damaged or stripped, some PuO_2 could be vaporized. If the graphite components remain intact, any vaporized fuel release would be limited to that which permeates through the graphite components. A release which permeates through the graphite components would be a very small fraction (about 1/1000) of that potentially vaporized fuel associated with a bare clad. A small fraction of early launch accidents could lead to intact impact of various spacecraft/launch vehicle configurations, as described above. The resulting impact could lead to mechanical damage of the RHU graphite components, depending on the orientation and velocity at impact, and subsequent exposure to burning Star 48B solid propellant, which could potentially lead to PuO_2 releases.

In later phases of the mission, accidents could lead to reentry heating and ground impact environments. However, the RHU would survive these potential reentry environments and subsequent surface impacts.

The Cm-244 and Co-57 small-quantity radioactive sources used in spacecraft instrumentation have relatively low melting temperatures compared to PuO_2. Due to their functional requirements for use in the science instruments, these sources cannot be contained and their release in the thermal environment of launch area accidents would be likely. Reentry conditions would also likely lead to the release of the small-quantity radioactive sources at high altitudes.

A summary of the accident and source term probabilities by mission phase are presented in Table 4-5. A summary of the radionuclide contributions to the source terms (Pu-238, Cm-244, and Co-57) are presented in Table 4-6 in terms of the mean and 99th percentile values. The 99th percentile source term is the value predicted to be exceeded only one percent of the time (1 in 100), given the release of the respective radionuclide in an accident. Essential features of the results for the MER–A mission are summarized below.

- <u>Phase 0 (Pre-Launch)</u>: During the pre-launch period and prior to launch vehicle liftoff, on-pad accidents could result in a release at a total probability of 6.3×10^{-5} (1 in 16,000). The source terms (mean and 99th percentile) are estimated to be 0.12 and 0.31 Ci for Pu-238; 0.028 and 0.028 Ci for Cm-244; and 0.10 and 0.10 Ci for Co-57.
- <u>Phase 1 (Early Launch)</u>: During Phase 1 from liftoff to 23 s, after which land impacts in the launch area are unlikely, the total probability of a release of any radioactive material is 9.0×10^{-4} (1 in 1,100). The source terms (mean and 99th percentile) are estimated to be 0.47 and 1.6 Ci for Pu-238 (at a lower total probability of 1.4×10^{-4} (1 in 7,200)); 0.009 and 0.027 for Cm-244; and 0.034 and 0.099 Ci for Co-57.
- <u>Phase 2 (Late Launch)</u>: In Phase 2, most accidents lead to impact of debris in the Atlantic Ocean, and at-altitude environments are not severe enough to lead to releases. Some AICs during Phase 2 could lead to degraded launch vehicle performance, causing a sub-orbital reentry or a subsequent orbital reentry at later times after Phase 2. Prior to achieving Earth orbit, those accidents could lead to

sub-orbital reentry within minutes. Following spacecraft breakup during reentry, about 2% of sub-orbital reentries could result in impacts of RHUs along portions of the vehicle flight path over southern Africa, Madagascar, and western Australia. Accidents which might occur after reaching orbit could result in orbital reentries from minutes to years after the accident. Orbital reentries would lead to surface impacts between 28º South and 28º North latitudes. The reentry heating conditions lead to the high-altitude release of the small-quantity radioactive sources with a total probability of 7.8×10^{-4} (1 in 1,300). The source terms (mean and 99th percentile) are estimated to be 0.025 and 0.049 Ci for Cm-244; and 0.088 and 0.18 Ci for Co-57.

- Phase 3 (Pre-Orbit/Orbit): Accidents during Phase 3 could lead to sub-orbital or orbital reentry conditions with a total probability of release for the small-quantity radioactive sources of 1.7×10^{-4} (1 in 5,900). The source terms would be identical to those estimated for Phase 2.
- Phase 4 (Orbit/Escape): Accidents during Phase 4 could lead to orbital reentry conditions with a total probability of release for the small-quantity radioactive sources of 2.5×10^{-3} (1 in 400). The source term ranges would be identical to those estimated for Phase 2.

Table 4-5. Accident and Source Term Probability Summary

Mission Phase	AIC Probability	Conditional Probability [a]		Total Probability [b]
		Pu-238	Cm-244/Co-57	
MER–A Mission				
0 (Pre-Launch)	1.16×10^{-4}	5.42×10^{-1}	5.42×10^{-1}	6.29×10^{-5}
1 (Early Launch)	4.69×10^{-3}	2.96×10^{-2}	1.92×10^{-1}	9.01×10^{-4}
2 (Late Launch)	2.42×10^{-2}	-	3.23×10^{-2}	7.82×10^{-4}
3 (Pre-Orbit/Orbit)	3.35×10^{-4}	-	5.00×10^{-1}	1.67×10^{-4}
4 (Orbit/Escape)	2.85×10^{-3}	-	8.88×10^{-1}	2.53×10^{-3}
Overall Mission	$\mathbf{3.22\times10^{-2}}$	$\mathbf{6.27\times10^{-3}}$	$\mathbf{1.38\times10^{-1}}$	$\mathbf{4.44\times10^{-3}}$
MER–B Mission				
0 (Pre-Launch)	1.16×10^{-4}	5.42×10^{-1}	5.42×10^{-1}	6.29×10^{-5}
1 (Early Launch)	3.29×10^{-3}	3.31×10^{-2}	1.87×10^{-1}	6.15×10^{-4}
2 (Late Launch)	2.25×10^{-2}	-	3.11×10^{-2}	7.00×10^{-4}
3 (Pre-Orbit/Orbit)	2.79×10^{-4}	-	5.00×10^{-1}	1.39×10^{-4}
4 (Orbit/Escape)	2.93×10^{-3}	-	8.90×10^{-1}	2.61×10^{-3}
Overall Mission	$\mathbf{2.91\times10^{-2}}$	$\mathbf{5.90\times10^{-3}}$	$\mathbf{1.48\times10^{-1}}$	$\mathbf{4.13\times10^{-3}}$

Source: DOE 2002

a. Conditional probability of release given the AIC probability.
b. Total probability of a release, calculated as the product of the AIC probability times the larger of the Pu-238 or Cm-244/Co-57 conditional release probabilities.

Table 4-6. Source Term Summary

Mission Phase	Pu-238 Mean	Pu-238 99th Percentile	Cm-244 Mean	Cm-244 99th Percentile	Co-57 Mean	Co-57 99th Percentile
	Source Term [a] (curies)					
MER–A Mission						
0 (Pre-Launch)	1.19×10^{-1}	3.06×10^{-1}	2.76×10^{-2}	2.81×10^{-2}	1.03×10^{-1}	1.05×10^{-1}
1 (Early Launch)	4.66×10^{-1}	1.55×10^{0}	9.05×10^{-3}	2.71×10^{-2}	3.41×10^{-2}	9.94×10^{-2}
2 (Late Launch)	-	-	2.50×10^{-2}	4.90×10^{-2}	8.80×10^{-2}	1.75×10^{-1}
3 (Pre-Orbit/Orbit)	-	-	2.50×10^{-2}	4.90×10^{-2}	8.80×10^{-2}	1.75×10^{-1}
4 (Orbit/Escape)	-	-	2.50×10^{-2}	4.90×10^{-2}	8.80×10^{-2}	1.75×10^{-1}
Overall Mission	$\mathbf{3.58 \times 10^{-1}}$	$\mathbf{1.16 \times 10^{0}}$	$\mathbf{2.18 \times 10^{-2}}$	$\mathbf{4.43 \times 10^{-2}}$	$\mathbf{7.73 \times 10^{-2}}$	$\mathbf{1.50 \times 10^{-1}}$
MER–B Mission						
0 (Pre-Launch)	1.19×10^{-1}	3.06×10^{-1}	2.76×10^{-2}	2.81×10^{-2}	1.03×10^{-1}	1.05×10^{-1}
1 (Early Launch)	5.78×10^{-1}	1.55×10^{0}	9.73×10^{-3}	2.68×10^{-2}	3.66×10^{-2}	9.76×10^{-2}
2 (Late Launch)	-	-	2.50×10^{-2}	4.90×10^{-2}	8.80×10^{-2}	1.75×10^{-1}
3 (Pre-Orbit/Orbit)	-	-	2.50×10^{-2}	4.90×10^{-2}	8.80×10^{-2}	1.75×10^{-1}
4 (Orbit/Escape)	-	-	2.50×10^{-2}	4.90×10^{-2}	8.80×10^{-2}	1.75×10^{-1}
Overall Mission	$\mathbf{4.10 \times 10^{-1}}$	$\mathbf{1.09 \times 10^{0}}$	$\mathbf{2.28 \times 10^{-2}}$	$\mathbf{4.54 \times 10^{-2}}$	$\mathbf{8.06 \times 10^{-2}}$	$\mathbf{1.62 \times 10^{-1}}$

Source: DOE 2002

a. Source terms for each radionuclide given a release of that radionuclide at the corresponding conditional probabilities in Table 4-5.

The total probabilities of release, source term ranges, and release characteristics for the MER–B mission are very similar to those estimated for the MER–A mission, as evident from Tables 4-5 and 4-6.

4.1.5 Environmental Consequences and Risks of Potential MER–2003 Project Radiological Accidents

This section is summarized from the DOE's *Nuclear Risk Assessment for 2003 Mars Exploration Rover Project Environmental Impact Statement* (DOE 2002). Health effect consequences stemming from potential PuO_2 and small-quantity radioactive source releases have been determined from atmospheric transport and dispersion simulations incorporating both launch-site specific and worldwide meteorological and population data. Biological effects models, based on methods prescribed by the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP), were applied to predict the number of excess latent cancer fatalities (health effects) induced in a 50-year period following a MER–2003 launch accident that results in a release of radioactive material.

4.1.5.1 Radiological Consequences

The radiological consequences of a given accident scenario that results in a radiological release have been estimated by DOE in terms of (1) maximum individual dose, (2) collective dose, (3) health effects, and (4) land area contaminated at or above specified levels.

The maximum individual dose is the dose that the person with the highest exposure would receive for a specific accident. Collective dose is the sum of the radiation dose received by all individuals exposed to radiation from a given release in units of "person-rem." The health effects represent excess latent cancer fatalities induced by releases, determined using ICRP estimators of 5×10^{-4} fatalities per person-rem for the general population and 4×10^{-4} for workers (ICRP 1990). It is recognized that another measure of radiological consequence is total detriment. Total detriment, as defined by ICRP, includes consideration of fatal cancers, non-fatal cancers, and hereditary effects in the exposed population, encompassing consideration of all age groups, including children. It is determined using total detriment estimators of 7.3×10^{-4} effects per person-rem for the general population and 5.6×10^{-4} for workers. Further details on total detriment can be found in DOE's risk assessment (DOE 2002).

Health effects estimators, which relate health effects to effective dose, are based on the assumption that the health effects vary directly with dose (*i.e.*, a linear, non-threshold model). This means that the contribution to health effects decreases linearly as the dose decreases to zero.

A summary of the radiological consequences by mission phase is presented in Table 4-7 in terms of the mean and 99th percentile values. The 99th percentile radiological consequence is the value predicted to be exceeded only one percent of the time (1 in 100) given an accident with a release. Essential features of the results for the MER–A mission, given a radiological release, are summarized below.

- <u>Phase 0 (Pre-Launch)</u>: The radiological consequences (mean and 99th percentile) are estimated to be: maximum individual dose, 0.011 and 0.39 rem; collective dose, 39 and 207 person-rem; and health effects, 0.019 and 0.10.
- <u>Phase 1 (Early Launch)</u>: The radiological consequences (mean and 99th percentile) are estimated to be: maximum individual dose, 0.006 and 0.085 rem; collective dose, 20 and 332 person-rem; and health effects, 0.010 and 0.16.
- <u>Phase 2 (Late Launch)</u>: The radiological consequences (mean and 99th percentile) are estimated to be: maximum individual dose, 2.2×10^{-6} and 6.3×10^{-6} rem; collective dose, 2.6 and 7.5 person-rem; and health effects, 0.0013 and 0.0038.
- <u>Phases 3 (Sub-Orbit/Orbit) and 4 (Orbit/Escape)</u>: The radiological consequences for Phases 3 and 4 are identical to those for Phase 2.

The ranges in the various types of radiological consequences for the MER–B mission are very similar to those estimated for the MER–A mission, as evident from Table 4-7.

Table 4-7. Radiological Consequences Summary

Mission Phase	Maximum Individual Dose (rem)		Collective Dose (person-rem)		Health Effects [a]	
	Mean	99th Percentile	Mean	99th Percentile	Mean	99th Percentile
MER–A Mission						
0 (Pre-Launch)	1.11×10^{-2}	3.92×10^{-1}	3.87×10^{1}	2.07×10^{2}	1.89×10^{-2}	1.03×10^{-1}
1 (Early Launch)	5.56×10^{-3}	8.54×10^{-2}	2.00×10^{1}	3.32×10^{2}	9.80×10^{-3}	1.58×10^{-1}
2 (Late Launch)	2.16×10^{-6}	6.34×10^{-6}	2.62×10^{0}	7.54×10^{0}	1.31×10^{-3}	3.77×10^{-3}
3 (Pre-Orbit/Orbit)	2.16×10^{-6}	6.34×10^{-6}	2.62×10^{0}	7.54×10^{0}	1.31×10^{-3}	3.77×10^{-3}
4 (Orbit/Escape)	2.16×10^{-6}	6.34×10^{-6}	2.62×10^{0}	7.54×10^{0}	1.31×10^{-3}	3.77×10^{-3}
Overall Mission [b]	**1.29×10^{-3}**	**2.29×10^{-2}**	**6.66×10^{0}**	**7.62×10^{1}**	**3.29×10^{-3}**	**3.65×10^{-2}**
MER–B Mission						
0 (Pre-Launch)	2.46×10^{-3}	3.38×10^{-2}	3.11×10^{1}	2.29×10^{2}	1.54×10^{-2}	1.14×10^{-1}
1 (Early Launch)	1.73×10^{-3}	2.42×10^{-2}	2.23×10^{1}	2.40×10^{2}	1.10×10^{-2}	1.19×10^{-1}
2 (Late Launch)	2.16×10^{-6}	6.34×10^{-6}	2.62×10^{0}	7.54×10^{0}	1.31×10^{-3}	3.77×10^{-3}
3 (Pre-Orbit/Orbit)	2.16×10^{-6}	6.34×10^{-6}	2.62×10^{0}	7.54×10^{0}	1.31×10^{-3}	3.77×10^{-3}
4 (Orbit/Escape)	2.16×10^{-6}	6.34×10^{-6}	2.62×10^{0}	7.54×10^{0}	1.31×10^{-3}	3.77×10^{-3}
Overall Mission [b]	**2.97×10^{-4}**	**4.13×10^{-3}**	**5.99×10^{0}**	**4.56×10^{1}**	**2.98×10^{-3}**	**2.26×10^{-2}**

Source: DOE 2002

a. Based on ICRP health effects estimators of 4×10^{-4} health effects per person-rem for workers and 5×10^{-4} health effects per person-rem for the general population (ICRP 1990).
b. Overall mission values are weighted by total probability of release for each mission phase (see Table 4-5).

Potential land contamination was evaluated in terms of 1) areas exceeding various screening levels (0.1 and 0.2 microcuries per square meter (μCi/m^2)), and 2) dose-rate related criteria (15, 25, and 100 millirem/yr) considered by the EPA, the Nuclear Regulatory Commission (NRC), and DOE in evaluating the need for land cleanup following radioactive contamination. The results indicated that mean values of land area contaminated at levels exceeding 0.1 and 0.2 μCi/m^2 (the latter being an EPA screening level used in the past to determine the need for further action, such as monitoring or cleanup, and considered in the risk analyses of previous missions) was less than 0.5 square kilometer (0.2 square mile) for all postulated pre-launch and launch phase accidents, and less than 1.0 square kilometer (0.4 square mile) at the 99th percentile level. The results indicated that dose-related criteria (15, 25, and 100 millirem/yr) developed using a risk-based approach could be exceeded during the first year, due primarily to resuspension, but dose rates would fall well below these levels after the first year. Dose rates after the first year would be well below the dose-rate criteria for remedial action, which in any case would require several years to implement following detailed evaluation and monitoring. When considered with respect to the lifetime risk levels associated with these annual dose rates, the lifetime risks would be well below the EPA lifetime-risk criterion from which the average annual dose rate criterion of 15 millirem/yr was derived. It is anticipated that no remedial action would be considered necessary on the basis of the dose rate criterion. Local remedial action at the accident site would be necessary to locate and recover the RHUs, small quantity sources, and cleanup any residual radioactive materials and contamination.

4.1.5.2 Mission Risks

A summary of the mission risks is presented in Table 4-8. For the purpose of this FEIS, risk is defined as the expectation of health effects in a statistical sense (*i.e.*, the product of total probability of release multiplied by the health effects resulting from a release, and then summed over all conditions leading to a release). The risk is determined for each mission phase and the overall mission. Since the potential health effects resulting from a release are the sum of each individual's probability of a health effect in the exposed population, risk can also be interpreted as the total probability of one health effect given a launch accident resulting in a release during the mission. The overall risks for the MER–A and MER–B missions is estimated to be 1.5 x 10^{-5} and 1.2 x 10^{-5}, respectively. The combined risk for both missions is the sum of these two values, or 2.7 x 10^{-5}.

Table 4-8. Mission Risk Summary

Mission Phase	AIC Probability	Conditional Probability	Total Probability	Mean Health Effects	Mission Risks
MER–A Mission					
0 (Pre-Launch)	1.16×10^{-4}	5.42×10^{-1}	6.29×10^{-5}	1.89×10^{-2}	1.19×10^{-6}
1 (Early Launch)	4.69×10^{-3}	1.92×10^{-1}	9.01×10^{-4}	9.80×10^{-3}	8.83×10^{-6}
2 (Late Launch)	2.42×10^{-2}	3.23×10^{-2}	7.82×10^{-4}	1.31×10^{-3}	1.02×10^{-6}
3 (Pre-Orbit/Orbit)	3.35×10^{-4}	5.00×10^{-1}	1.67×10^{-4}	1.31×10^{-3}	2.19×10^{-7}
4 (Orbit/Escape)	2.85×10^{-3}	8.88×10^{-1}	2.53×10^{-3}	1.31×10^{-3}	3.31×10^{-6}
Overall Mission	$\mathbf{3.22\times10^{-2}}$	$\mathbf{1.38\times10^{-1}}$	$\mathbf{4.44\times10^{-3}}$	$\mathbf{3.29\times10^{-3}}$	$\mathbf{1.46\times10^{-5}}$
MER–B Mission					
0 (Pre-Launch)	1.16×10^{-4}	5.42×10^{-1}	6.29×10^{-5}	1.54×10^{-2}	9.68×10^{-7}
1 (Early Launch)	3.29×10^{-3}	1.87×10^{-1}	6.15×10^{-4}	1.10×10^{-2}	6.77×10^{-6}
2 (Late Launch)	2.25×10^{-2}	3.11×10^{-2}	7.00×10^{-4}	1.31×10^{-3}	9.16×10^{-7}
3 (Pre-Orbit/Orbit)	2.79×10^{-4}	5.00×10^{-1}	1.39×10^{-4}	1.31×10^{-3}	1.83×10^{-7}
4 (Orbit/Escape)	2.93×10^{-3}	8.90×10^{-1}	2.61×10^{-3}	1.31×10^{-3}	3.41×10^{-6}
Overall Mission	$\mathbf{2.91\times10^{-2}}$	$\mathbf{1.48\times10^{-1}}$	$\mathbf{4.13\times10^{-3}}$	$\mathbf{2.98\times10^{-3}}$	$\mathbf{1.23\times10^{-5}}$

Source: DOE 2002

Phase 1 accidents represent 60% of the radiological risk for the MER–A mission and 55% of that for the MER–B mission. FSIIs followed by second stage/Star 48B/spacecraft/PLF impacts are the primary contributors to the Phase 1 risk.

The relative contributions of Pu-238, Cm-244, and Co-57 to the mission risks, summarized in Table 4-9, are estimated to be 57%, 43%, and 0.13%, respectively, for both missions combined.

Table 4-9. Mission Risk Contributions by Radionuclide

Mission	Overall Mission Risk			
	Pu-238	Cm-244	Co-57	Total
MER–A	8.54×10^{-6}	6.03×10^{-6}	1.82×10^{-8}	1.46×10^{-5}
MER–B	6.74×10^{-6}	5.51×10^{-6}	1.76×10^{-8}	1.23×10^{-5}
Both Missions	$\mathbf{1.53 \times 10^{-5}}$	$\mathbf{1.15 \times 10^{-5}}$	$\mathbf{3.58 \times 10^{-8}}$	$\mathbf{2.69 \times 10^{-5}}$

Source: DOE 2002

The relative contributions of risks in the launch area (*i.e.*, the regional area of interest within 100 km (62 mi) of SLC–17) and on a global scale, summarized in Table 4-10, are estimated to be 35% and 65% respectively, for both missions combined. Estimated launch area risks are based on accidents that occur during Phases 0 and 1. The risks beyond the launch area are due to accidents in all mission phases with Phase 1 the primary contributor due to long range transport of releases beyond 100 km (62 mi) from SLC–17.

Table 4-10. Mission Risk Contributions by Affected Region

Mission	Overall Mission Risk		
	Launch Area [a]	Global [b]	Total
MER–A	5.55×10^{-6}	9.02×10^{-6}	1.46×10^{-5}
MER–B	3.88×10^{-6}	8.37×10^{-6}	1.23×10^{-5}
Both Missions	$\mathbf{9.43 \times 10^{-6}}$	$\mathbf{1.74 \times 10^{-5}}$	$\mathbf{2.69 \times 10^{-5}}$

Source: DOE 2002

a. The regional area of interest within 100 km (62 mi) from the launch site for Phases 0 and 1.
b. Beyond 100 km (62 mi) from the launch site for Phases 0 and 1, and worldwide for Phases 2 to 4.

Another descriptor used in characterizing risk is the average individual risk (see Table 4-11), defined in this FEIS as the risk divided by the number of persons exposed. The average individual risk, interpreted as an individual's average incremental probability of incurring a health effect given the mission, is estimated to be 9.4×10^{-11} in the launch area (within 100 km (62 mi) of SLC–17) and 5.8×10^{-15} on a global scale for both missions combined. The primary contributors to the average individual risk are Phase 1 accidents.

Some individuals within the exposed population, such as those very close to the launch area, would face higher risks. The risk to the maximally exposed individual is defined in this FEIS as the total probability of a release multiplied by the risk of a latent cancer fatality to that individual. Table 4-11 summarizes these risks. The risk to the potentially maximally exposed individual within the launch area population is about 2.9×10^{-9} (1 in 350 million) for the MER–A mission and about 6.1×10^{-10} (1 in 1.6 billion) for the MER–B mission.

Table 4-11. Individual Risk Contributions by Affected Region

Mission	Average Individual Risk [a]		Maximum Individual Risk [d]	
	Launch Area [b]	Global [c]	Launch Area	Global
MER–A	$5.55x10^{-11}$	$3.01x10^{-15}$	$2.85x10^{-9}$	$3.76x10^{-12}$
MER–B	$3.88x10^{-11}$	$2.79x10^{-15}$	$6.09x10^{-10}$	$3.72x10^{-12}$
Both Missions	**$9.43x10^{-11}$**	**$5.80x10^{-15}$**	**$3.46x10^{-9}$**	**$7.48x10^{-12}$**

Source: Adapted from DOE 2002

a. Mission risk contribution in the affected area divided by the number of persons exposed.
b. The regional area of interest within 100 km (62 mi) of the launch site for Phases 0 and 1. Based on an exposed population on the order of 10^5 persons.
c. Beyond 100 km (62 mi) from the launch site for Phases 0 and 1, and worldwide for Phases 2 to 4. Based on an exposed population on the order of 3×10^9 persons.
d. Within 100 km (62 mi) of the launch site, the maximum individual risks are summed over Phases 0 and 1. Beyond 100 km (62 mi) from the launch site, the maximum individual risks are summed over Phases 2 through 4.

These risk estimates are clearly very small relative to other risks. For example, Table 2-7 presents information on annual individual fatality risk to U.S. residents due to various types of hazards. This table indicates that the average individual risk of accidental death in the U.S. is about 3.5×10^{-4} (1 in 2,900) per year.

4.1.5.3 Uncertainty

A detailed uncertainty analysis has not been performed as part of the risk assessment prepared for this FEIS. Based on uncertainty analyses performed for previous mission risk assessments (*e.g.*, NASA 1997), parameter and model uncertainties associated with estimating radiological consequences could result in risk estimates that vary from one to two orders of magnitude higher (at the 95% confidence level) or lower (at the 5% confidence level) relative to the estimates presented in Sections 4.1.5.1 and 4.1.5.2.

4.1.6 Radiological Emergency Response Planning

Prior to the launch of the MER–2003 missions with the RHUs and small quantity radioactive sources onboard each rover, NASA, as the Lead Federal Agency, would develop a comprehensive plan in accordance with the Federal Radiological Emergency Response Plan. This plan would ensure that any accident would be met with a well-developed and tested response. The plan would be developed through the combined efforts of Federal agencies (*e.g.*, NASA, DOE, the U.S. Department of Defense (DoD), EPA, the Federal Emergency Management Agency, and others as appropriate), the State of Florida, and local organizations involved in local emergency response.

A Radiological Control Center would coordinate any emergency actions required during the pre-launch countdown or the early phases of the mission. In the event of an accident, a nearby offsite location would be established to conduct monitoring and surveillance in areas outside the launch site, assess the accumulated data, and coordinate further actions through the Radiological Control Center.

The response to launch accidents would also depend on the geographical locations involved. Accident sites within the United States and U.S. Territories may be supported initially by the nearest Federal installation possessing a radiological contingency response capability. Personnel from all supporting installations would be alerted to this potential requirement prior to launch. Additional support would be dispatched from the launch site support personnel or from other support agencies, as needed. For accidents occurring outside the United States or its territorial jurisdictions, the U.S. Department of State and diplomatic channels would be employed in accordance with pre-arranged procedures and support elements would be dispatched as appropriate.

If an ocean or water impact occurs, the Federal agencies would undertake security measures, as appropriate, and search and retrieval operations. The recovery of the plutonium dioxide would be based on the technological feasibility, the health hazard presented to recovery personnel, the environmental impacts, and other pertinent factors.

4.2 ENVIRONMENTAL IMPACTS OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, preparations for the MER–2003 project would be discontinued, and the MER–2003 missions would not be implemented. None of the physical, geological, and chemical scientific investigations planned for the proposed MER–2003 missions would be achieved. Furthermore, lessons expected to be learned during all phases of each mission (atmospheric entry, descent, and landing; initial deployment on the surface; real-time site traverse planning, execution and navigation; simultaneous operation of two rovers; and science data collection) would not be gained. Canceling this project would thus lead to a significant gap in NASA's scientific objectives for exploring Mars and would adversely affect NASA's plans for future missions to Mars. There would be neither adverse environmental impacts nor beneficial effects with the No Action Alternative.

4.3 CUMULATIVE IMPACTS

Within the CCAFS regional area, cumulative impacts of exhaust emissions from the MER–2003 launch vehicles would not substantially affect long-term air quality, water quality, and biotic resources. Launching the MER–2003 missions also would not cause any changes in land use at or in the vicinity of CCAFS.

From a cumulative environmental impact perspective, launch of the MER–2003 missions from CCAFS would principally contribute to exhaust emissions impacts on and near the launch pads. Over the period between May 1995 and January 1998, NASA monitored 46 Atlas, Delta II, and Titan IV launches from CCAFS (USAF 1998). Within 70 to 100 m (230 to 330 ft) of the flame trenches, vegetation was scorched and trees were partially or completely defoliated. Deposition of large particulates was found in this area out to about 200 m (660 ft) from the flame trench of the Titan IV launch complex, with small particulate deposition and evidence of low-concentration acidic deposition found between 250 and 830 m (820 and 2,720 ft) from the Delta II launch complex. While these impacts may persist with continued use of a launch site, and the MER–2003 launches would contribute to these conditions, they are probably not irreversible. NASA (Schmalzer *et al.* 1998) found that vegetation reestablished itself after cessation of launches in similarly affected areas near the Space Shuttle launch pads.

On a short-term basis, the two MER–2003 launches would contribute to the addition of ozone depleting substances (about 0.02 kg (0.05 lb)) to the stratosphere. The total contribution of the two launches to the average annual depletion of ozone would be extremely small (about 0.0025% for both launches on a global annual average basis). See Section 4.1.2.3 for further discussion.

4.4 ENVIRONMENTAL IMPACTS THAT CANNOT BE AVOIDED

During a normal launch of both the Delta II 7925 (NASA 1998a) and the Delta II 7925H, the Delta II main engine and ground-lit GEMs would be ignited shortly prior to lift-off and would produce an exhaust cloud. This exhaust cloud, consisting of Al_2O_3, CO, HCl, and relatively smaller amounts of CO_2, H_2, H_2O, N_2, Cl and NO_X, would be concentrated near the launch pad during the first moments of launch. Thereafter, the exhaust cloud would be transported downwind and upward, and would dissipate. Aluminum oxide (Al_2O_3) particulates would also be deposited at the launch site as the exhaust cloud travels downwind.

Biota in the immediate vicinity of the launch pad could be damaged or killed by the intense heat and HCl deposition from the exhaust cloud. No long-term adverse effects to biota would be anticipated at either launch pad of SLC–17 (USAF 1996; NASA 1998a; NASA 1998b; NASA 2002).

4.5 INCOMPLETE OR UNAVAILABLE INFORMATION

The primary areas of either incomplete or unavailable information for the MER–2003 project include the following items.

This FEIS evaluates launch accident scenarios that could potentially result in a release from the RHUs and small quantity radioactive sources onboard the MER–2003 rovers. NASA and DOE are continuing to evaluate factors potentially affecting mission safety and risks. Should any of the ongoing evaluations result in risk estimates greater than those presented in this FEIS, NASA will consider the new information, and determine the need for additional NEPA documentation.

A detailed uncertainty analysis has not been performed as part of the risk assessment prepared for this FEIS. Based on uncertainty assessments performed for previous mission safety analyses (*e.g.*, NASA 1997), parameter and model uncertainties associated with estimating radiological consequences could result in risk estimates that vary from one to two orders of magnitude at the 5% and 95% confidence levels.

4.6 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE HUMAN ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

4.6.1 Short-Term Uses

The MER–2003 missions would be launched from CCAFS. The short-term affected environment would include this launch site and surrounding areas. At CCAFS, short-term uses include NASA and USAF operations, urban communities, a fish and wildlife refuge, citrus groves, residential communities, and recreational areas (NASA 1995). The MER–2003 mission would be conducted in accordance with past and ongoing NASA and USAF procedures for operations at a CCAFS launch site. Should an accident occur at CCAFS causing a radiological release, short-term uses of contaminated areas could be curtailed, pending mitigation.

4.6.2 Long-Term Productivity

No changes to land use at CCAFS or the surrounding region would be anticipated because of the two MER–2003 launches from SLC–17. The region would continue to support human habitation and activities, wildlife habitats, citrus groves, and grazing/agricultural land. No long-term effects on these uses would be anticipated because of the MER–2003 missions. However, should an accident occur at CCAFS causing a radiological release, the long-term productivity of contaminated land areas could be impacted.

The successful completion of the MER–2003 missions would benefit the U.S. space program, which is important to the economic stability of the area surrounding the launch site. In addition to the localized economic benefits, implementing the MER–2003 missions has broader socioeconomic benefits. These include technology spin-offs to industry and other space missions, maintaining the unique capability of the U.S. to conduct complex planetary missions by scientists and engineers, and supporting the continued scientific development of graduate students at universities and colleges. Furthermore, real-time data and images acquired by the MER–2003 rovers would be made available to the general public, schools, and other institutions via a broad variety of media, including the Internet.

4.7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

An irretrievable resource commitment results when a spent resource cannot be replaced within a reasonable period of time. For the Proposed Action, quantities of various resources, including energy, fuels, and other materials, would be irreversibly and irretrievably committed. The use of these resources would be associated with the fabrication, launch, and operation of the MER–2003 project.

4.7.1 Energy and Fuels

The fabrication processes for the MER–2003 spacecraft and launch vehicles would use electrical and fossil fuel energy. This use constitutes an irretrievable commitment of resources but would not impose any significant energy impacts. The launch and operation of the spacecraft would consume solid and liquid propellants. The solid propellant ingredients, primarily in the Star 48B motors and GEMs, would be ammonium perchlorate, aluminum powder, and HTPB binder. The liquid propellants would include RP-1, LOX, Aerozine–50, and N_2O_4 in the Delta II core vehicles and hydrazine in the MER–2003 cruise stages. The quantities that would be used for the MER–2003 missions are discussed in Sections 2.1.1, 2.1.5 and 2.1.6.

4.7.2 Other Materials

The total quantities of other materials used in the MER–2003 missions that would be irreversibly and irretrievable committed are relatively minor. Typically, these materials include steel, aluminum, titanium, iron, molybdenum, plastic, glass, nickel, chromium, lead, zinc, and copper. Less common materials may include small quantities of silver, mercury, gold, rhodium, gallium, germanium, hafnium, niobium, platinum, plutonium, and tantalum.

4.8 ENVIRONMENTAL COMPLIANCE AT CCAFS

This section presents an overview of the environmental reviews and consultation requirements for CCAFS, which include permits, licenses, and approvals.

Air Resources

Air quality in Florida, and consequently at CCAFS, is managed by the Florida Department of Environmental Protection (FDEP) through a Federal, State, and local regulatory framework.

Air permits are required for activities having the potential to release air pollutants. CCAFS is required to have necessary air permits and currently operates under Title V (40 CFR 70) of the Clean Air Act (CAA) as a single facility (USAF 1998).

Air permits are not required for emissions from mobile sources such as motor vehicles, aircraft, and space launch vehicles, but are required for support activities such as launch vehicle preparation, assembly, and propellant loading which are considered stationary sources. Since existing equipment and services would be used for the proposed MER–2003 project and there would be no new construction of stationary sources, there would be no requirement to obtain new air permits or modify the existing Title V permit.

The Delta II oxidizer and fuel vapor air pollution control devices at CCAFS comply with NAAQS and FDEP regulations. The citric acid scrubber for Delta II propellants is probably one level of control beyond that required by FDEP (NASA 2002).

Water Resources

Wastewater discharge from CCAFS is regulated by the FDEP through a permitting program which places limitations on the amount of pollutants discharged to the receiving waterways. Permits are also required for construction activities that involve areas greater than 2 hectares (5 acres) in extent for storm water management (USAF 1998).

Because the proposed MER–2003 project would be within the normal contingent of Delta II launches no new permits would be required for discharge of sanitary and industrial wastewater. Deluge and wash down water would be collected in the flame trench prior to discharge. The water would be tested and if regulatory requirements were met, would be discharged to grade under a FDEP discharge permit. If regulatory requirements cannot be met and the water cannot be released to grade, the wastewater would be treated and disposed by a certified contractor in accordance with applicable Federal, State, and local regulations (USAF 1998).

Floodplains and Wetlands

SLC–17 does not lie on a floodplain and is not located on a wetland. New permits would not be required since there would be no new construction or dredge and fill activities associated with the proposed MER–2003 project. The MER–2003 launches from SLC–17 would not add substantial impacts beyond those normally associated with any launch of a Delta II.

Hazardous Material Management

The USAF provides guidance for managing hazardous materials through Instruction AFI 32-7086, *Hazardous Material Management*. CCAFS hazardous material management is administered from Patrick Air Force Base through a hazardous material pharmacy distribution system (HazMart). Under the HazMart system, less toxic alternatives are examined prior to procuring the requisitioned item with distribution controls (USAF 1998). The proposed MER–2003 project would follow recommended guidelines for hazardous material management.

Hazardous Waste Management

Hazardous wastes generated during the preparation, processing, and launch operations of the proposed MER–2003 project at CCAFS would be managed as either Boeing commercial hazardous waste or as NASA hazardous waste in accordance with the 45th Space Wing's *Petroleum Products and Hazardous Waste Management Plan* (OPlan19-14) and under USAF Guidance AFI 32-7042, *Solid and Hazardous Waste Compliance* (USAF 1998). Any hazardous waste generated at the launch pad (usually negligible) would be returned to the spacecraft processing facility at KSC and disposed properly by Boeing in accordance with the Launch Site Support Plan and in compliance with applicable Federal, State, and local regulations.

Pollution Prevention

Pollution prevention guidelines at CCAFS are provided by DoD Directive 4210.15; USAF Policy Directive AFPD 32-70, *Environmental Quality*; USAF Instruction AFI 32-7080, *Pollution Prevention Program*; and the 45th Space Wing's *Pollution Prevention Program Guide and Pollution Prevention Management Action Plan* (USAF 1996). NASA also participates in a partnership with the military services, called the Joint Group on Pollution Prevention (JG-PP), to reduce or eliminate hazardous material or processes. The proposed MER–2003 project activities would follow appropriate guidelines.

Spill Prevention

CCAFS has a Spill Prevention, Control, and Countermeasures Plan which is developed with and integrated to the 45th Space Wing's *Hazardous Materials Response Plan* (OPlan 32-3). When a Federally listed oil or petroleum spill occurs, as per the 45th Space Wing's *Hazardous Substance Pollution Contingency Plan* (OPlan 19-4), the substance will be collected and removed for disposal by a certified contractor. In addition, per OPlan 32-3, all spill or releases would be reported (USAF 1996). The proposed MER–2003 project activities would follow appropriate guidelines.

Biological Resources

The region surrounding CCAFS is host to diverse species of fauna and flora, some of which are listed in the endangered and threatened category, including sensitive habitats. Biological resources at CCAFS are impacted by spacecraft launches (*e.g.*, from noise, the exhaust cloud) and other activities associated with launches. The proposed MER–2003 project would observe procedures which minimize impacting these resources, such as the lighting management plan used to minimize impacts to sea turtle nesting beaches.

Coastal Zone Management

The mandate to preserve the Nation's coastal zones is provided by the Federal Coastal Zone Management Act of 1972, which has established a national policy to preserve, protect, develop, restore, and/or enhance the resources of the nation's coastal zone. Management of Florida's coastal zones is delegated to the State. Federal activities that directly affect coastal zones are required to be consistent to the maximum extent practicable with the Florida Coastal Management Program. In Brevard County, a no-development zone has been established 23 m (75 ft) inland from the mean high water level. CCAFS has additional siting requirements extending to 46 m (150 ft) inland from the mean high water level (USAF 1998). The proposed MER–2003 project would not add substantial impacts beyond those normally associated with a Delta II launch, and therefore would be consistent with applicable regulations.

Cultural Resources

Section 106 of the National Historic Preservation Act of 1966, as amended, requires Federal agencies to consult with the State Historic Preservation Officer and the Federal Advisory Council on Historic Preservation if a proposed action has the potential to impact cultural resources. Implementation of the proposed MER-2003 project is not expected to adversely impact cultural resources within CCAFS. The Environmental Office at CCAFS will assure conformity with the regulations of the National Historic Preservation Act of 1966 (36 CFR part 800).

Noise

The Occupational Safety and Health Administration (OSHA) and the National Institute of Occupational Safety and Health provide guidelines for worker exposure to noise. The proposed MER–2003 project would follow prescribed guidelines.

Worker and Public Safety and Health

Worker safety and health guidelines including public health and safety guidelines provided by OSHA would be followed by the proposed MER–2003 project with respect to protection from noise, exposure to hazardous materials and hazardous wastes, and ingestion of toxic fumes such as from fueling operations. The 45th Space Wing has the responsibility to follow range safety guidelines as outlined in EWR 127-1, *Eastern and Western Range Safety Requirements* (USAF 1998).